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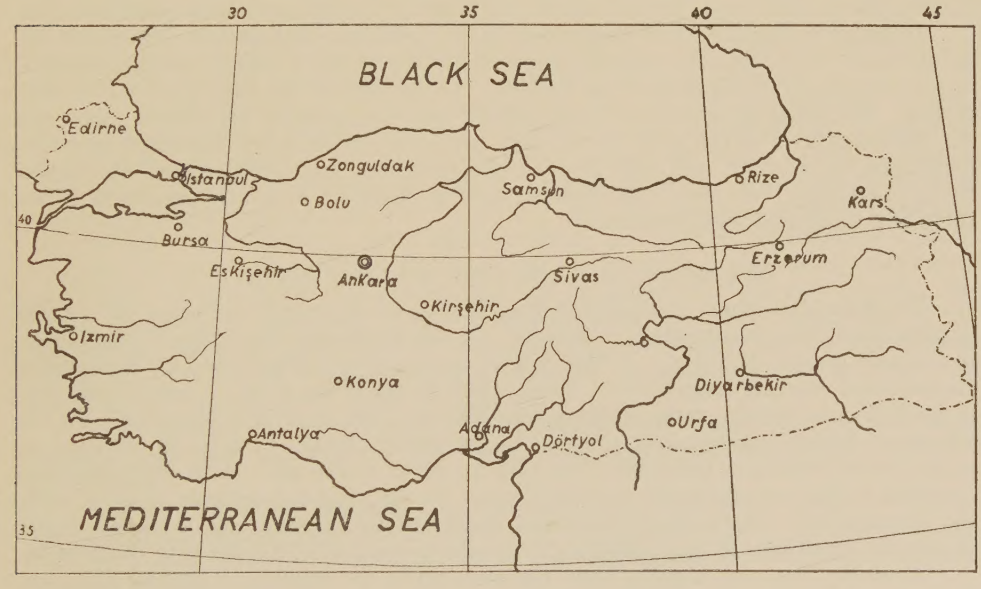
THE IMPORTANCE OF SOIL EROSION FOR THE INTENSIFICATION OF FIELD HUSBANDRY IN TURKEY

F. CHRISTIANSEN-WENIGER.
Ankara, Turkey.

[Translated from German by G. M. Roseveare]

ON account of its morphological structure Anatolia affords good opportunities in every part for assault by erosion. From earliest geological times it has been subjected to vast orogenetic processes, and in addition the whole block has been uplifted. Regions which were still covered by the sea in the Lower Tertiary have risen to a height of as much as 1,000 m. Where, therefore, climatic conditions are such as to promote erosion, it is certain to have very great effect.



TURKEY.

As we are well informed of the changes which have taken place on the coasts of Asia Minor in historical times, we are in the fortunate position of being able to obtain, through the alluvial deposits brought down by the rivers, a reliable impression of the results of erosion during the last two thousand years in these regions. A few data will serve to give us an approximate idea of their proportions.

The whole Cilician plain with its area of approximately 2,000 sq. km. is an early alluvial deposit, which is steadily increasing in size. Cleopatra's fleet sailed into the harbour of Tarsus, which to-day is an inland town situated 15 km. from the sea. Particularly impressive is the history of the mouth of the river the Great Menderez, in the valley of which the old harbour towns have been again and again surrounded by land and rebuilt on the receding seashore. The ruins of Mysus, the harbour of which was still in use as recently as 500 B.C., to-day lie 26 km. from the coast. The island of Lade, as recently as 496 B.C. the scene of a sea battle, is now a hill in the plain at the mouth of the river (cf. Wagner **5**). Tschikatscheff (**4**) calculates that the sea has receded at the mouth of the Great Menderez at the rate of approximately 600 m. per century within the last 1,900 years. As the breadth of the river mouth amounts to 15 km., that is equivalent to an average land increase of 9 sq. km. in 100 years. Similar results can also be proved for the other great rivers of Asia Minor.

The deposits at the mouths of the rivers, however, are not by any means the only evidence of erosion. The plains which are so characteristic of Anatolia, the "Ovas," are filled with tremendous masses of eroded material. Salomon-Calvi (**2**) estimates the depth of the alluvial soils of the Ova of Ankara at several hundred metres.

These facts demonstrate that enormous quantities of soil have been moved in recent years and that similar movement is still to be expected, since conditions have not altered. It will be our task to show what influence erosion exercises upon soil which is or may be used for agricultural purposes, and how the present activities of the Turkish farmers influence soil erosion. Finally we shall sketch those measures which, under the planned intensification and extension of husbandry, are requisite for the purpose of meeting, as far as possible, the risks of soil destruction and deterioration.

In order to gain a correct impression of the problems confronting Anatolia it will be necessary to review the morphological structure of the country and the climatic factors which are of importance for erosion. Of the former we shall give only a brief sketch. We must go somewhat more closely into the question of climate, confining our considerations in the main to temperature in so far as it has an effect upon the disintegration of rock and soil, and to precipitation, which represents the actual agent of erosion. We shall refer to wind only in relation to the arid regions in which there is a danger of wind erosion.

Morphological Structure of the Country.

The Anatolian block is separated from the sea on the north and south by a chain of high mountains surrounding a plateau. In the south-east the uplands slope down to the arid regions of Syria. In the east we have uplands intersected by depressions and marshes, forming large plains 1,200 to 2,000 m. above sea level. Central Anatolia, in itself much divided, is an upland area 800 to 1,000 m. above sea level. In the Vilayet of Konya, delimited on the east by the great salt lake (Tuz Geul), we have an extensive depression or basin-like area with no outlet to the sea. This depression was occupied in Miocene times by an inland sea. To the west the uplands slope down to the Aegean Sea. Here there are found deep valleys running east to west, which enable the maritime climatic influence to penetrate somewhat further into the interior.

Anatolia thus rises rapidly from the west up to the heights of central Anatolia. In eastern Anatolia the land rises still considerably higher. High mountain chains are situated at the confines, but the interior also is much divided and is characterized everywhere by much variation in altitude.

Climatic Conditions.

On the one hand the morphological structure of Anatolia, and on the other hand the situation of the peninsula between the Mediterranean Sea and the mainland of

Asia, result in a great variety of climatic conditions. For the purposes of this broad outline only the major differences can be taken into consideration, but it must not be forgotten that between the different climatic regions there exist transitional zones which often exhibit important peculiarities, and that within the large climatic regions also there are many disparities. [In "The principles of crop farming in Turkey" (**1**) an attempt has been made to work out the details more exactly. This book contains the draft of a climatic map of Turkey and a table of the principal climatic data.]

With the above-mentioned limitations, therefore, we will briefly consider the following regions: (1) the coastal regions; (2) central Anatolia; (3) south-east Anatolia; and (4) east Anatolia, basing our observations on the publications of the Meteorological Institute, Ankara.

All the coasts of Anatolia are characterized by moderate temperature, without frost of long duration and with small diurnal and annual variations. The mean for the year is 14°C. on the north coast, 17° on the west coast, and 18° to 20° on the south coast.

The annual amount of precipitation varies widely. On the eastern, Black Sea coast the average annual precipitation is 2,500 mm. per annum. In the western part of Anatolia and on the shores of the Aegean Sea, precipitation ranges from 600 to 1,000 mm. On the south coast at Antalya and Dörtyol it again exceeds the 1,000 mm. limit.

For our problem average precipitation is of little importance. Of greater interest is the maximal precipitation and the distribution of rainfall throughout the different seasons. This information is given in Table 1, which shows that the autumn and winter rains furnish the maximum precipitation on the north coast. On the west and south coasts, on the other hand, it is the winter which has by far the greatest rainfall, while there is extraordinarily little in summer.

Of special importance for soil erosion are the occasional rainstorms of cloud-burst intensity which bring about the action of tremendous quantities of water in a short time. A single heavy cloud-burst can sometimes cause severe damage to soils which would be scarcely affected by normal rainfall. It is difficult to obtain exact information concerning the frequency and the violence of these rainstorms, on account of the relatively short time for which the Turkish Meteorological Service has been in operation and the great gaps which still exist in the area covered by its activities. It is only by rare chance that the maximum of these cloud-bursts, often much localized, is recorded. Nevertheless, in order to obtain some idea of their proportions, we will quote here the figures which are available for the highest quantities recorded for 24 hours. There is, however, a possibility that in some cases much greater quantities of water actually fell.

The following maximum quantities of rain recorded for 24 hours in the coastal regions have been observed by the Meteorological Stations during the years 1928 to 1936 :

August 1928, Rize, **244 mm.** At the same place there were recorded in the four successive months September to December, 1931, daily maxima of 121 mm., 132 mm., 136 mm., and 130 mm. Other records for the same years include four daily quantities of 100 mm. and over.

Zonguldak : 1932 VI. 110 mm., 1931 VI. 127 mm.
Ordu : 1933 VII. 100 mm., VIII. 148 mm.
Canakkale : 1932 XI. 92 mm.
Izmit : 1931 VIII. 97 mm.
Bursa : 1935 X. 80 mm.
Izmir : 1930 IX. **231 mm.**
Mugla : 1935 X. 153 mm., XII. 103 mm.

Table 1. Coastal regions.

Place	Total annual precipitation		Precipitation at the different seasons							
			Average				Maximal			
	Mean	Maximum.	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
(a) North coast.										
Rize	2570	4045	393	574	840	732	672	659	1234	1865
Samsun	767	826	163	123	196	222	242	248	267	358
Zonguldak	1336	1970	206	327	467	357	424	645	671	457
(b) West coast.										
Bursa	641	880	168	55	175	243	268	159	344	350
Izmir	742	1030	162	13	193	363	256	35	488	515
(c) South coast.										
Antalya	1149	1645	159	23	187	754	321	790	456	1199
Adana	585	789	166	45	105	273	354	96	186	386

Table 2. Central Anatolia.

Ankara	317	423	122	42	153	100	204	101	100	144
Konya	292	410	103	34	53	102	158	61	107	220
Kirşehir	328	403	104	53	63	125	159	137	151	194
Eskişehir	320	411	105	43	66	105	160	103	93	173

Table 3. East Anatolia.

Kars	538	710	178	173	95	92	323	323	125	138
Erzurum	538	830	198	124	123	94	334	226	178	163
Sivas	384	542	144	45	78	115	212	86	157	164

Table. 4 South-east Anatolia.

Diyarbekir	405	568	131	10	87	177	238	18	183	243
Urfa	405	525	109	4	54	239	167	12	120	321
Malatya	343	493	113	22	80	127	174	59	201	199

Antalya : 1931 I. 173 mm., 1932 I. 146 mm., 1933 XI. 122 mm., 1934 XII. 139 mm., 1935 XI. 184 mm., 1936 I. **233 mm.**, XII. 149 mm.

Dörtyol : 1934 IV. 106 mm., 1931 V. 103 mm., VI. 115 mm.

In the coastal hinterland we find maximum quantities of 66 mm. recorded for Aydin, 64 mm. for Nazilli, 55 mm. for Denizli and 62 mm. for Manisa.

The average annual precipitation of the whole coastal region is 700 to 800 mm., and there is a maximal precipitation of 800 to 4,000 mm. within the short period under observation. On the north coast the greatest rainfall occurs in autumn and winter, on the west and south west coasts in winter. In all parts there is a risk of single heavy downpours, which in a short time bring large quantities of water into action.

Central Anatolia, cut off from the influence of the sea by the surrounding chain of mountains, in contrast to the coastal regions is not only an arid region, but has much more inequable temperature. The mean annual temperature varies from 10 to 12°C. The daily variations in temperature are considerable. In winter -20° and under are recorded. In late autumn temperatures alternating below and above freezing point are fairly frequent. They favour the disintegration of rock, since at the same time rainfall water is present.

The annual average precipitation is low. The maximum rainfall is in the spring (Table 2). Very important for erosion is the fact that towards the end of May and in June there may be a successive occurrence of thunder-storms which are often accompanied by heavy local downpours or cloud-bursts. This is the so-called "kirkikindi" (forty afternoon prayers). A thunder-storm is said to occur regularly on forty (kirk) days at the time of the afternoon prayer (ikindi). In spite of the limited area affected by the different thunder-storms, they are of great importance for erosion, since they are accompanied by the fall of tremendous quantities of water per unit area.

The maximum quantities of rain recorded within 24 hours in central Anatolia vary from 45 to 60 mm. The heaviest falls occur in the spring and early summer months. It is to be assumed that much greater cloud-bursts occur sometimes, even if rarely, especially in the mountains.

As the soil surface is dried up to an extraordinary degree in the summer, there is a danger of dust storms. Strong winds are able to blow up the fine earth from unprotected soil surfaces and to transport it in the form of dust. The following is the frequency of dust storms recorded by the Meteorological Institute at Ankara for the different months, 1926 to 1934 :

Average frequency of dust storms.

Months :	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dust storms	0	0	0.8	1	0.4	1.3	4.7	6.6	3.8	1	0.2	0

The highest number, 16, is recorded for the month of August, 1927.

Central Anatolia, with an average annual temperature of 11°C., has thus great diurnal and annual variation in temperature. Rainfall is low, with a spring maximum which brings frequent thunder-storms and rains of cloud-burst intensity. There is a danger of dust storms.

The east Anatolian climate is definitely continental, having very cold winters, relatively warm summers, and great diurnal and annual variation in temperature. Thus the mean annual temperature in Kars is 3.7°C., that for August 17.4°, and that for January -13.6°. The difference between the warmest and the coldest month thus amounts to 31°, whilst on the Black Sea littoral near by the difference is only 17°. The absolute annual extremes are 33° and -35° ; they are thus 68° apart.

Precipitation is not excessive (400 to 500 mm.) and a considerable part of it takes the form of snow. Maximum precipitation occurs in spring and summer (Table 3), possibly with sudden heavy rainstorms. The maxima actually recorded for 24 hours are 45 and 55 mm.

South-east Anatolia is characterized by a hot, dry climate. Annual mean temperature varies in accordance with altitude from 13° to 18°. The summer maxima exceed 40°. In winter there is frost. In Diyarbekir an absolute minimum of -24.2° was recorded. Thus, with an absolute maximum of 43.8°, the absolute annual variation hitherto recorded amounts to 68°.

Precipitation is low, ranging from 300 to 400 mm. There is a maximum in winter, while the summer is definitely dry. In spring violent rainstorms occur here also, the maximum recorded for 24 hours being 45 and 67 mm. (Table 4).

In dry periods, especially in spring, there is a danger of dust storms, which Zistler has described in detail as sirocco.

Finally brief reference must be made to the transitional climatic regions. For our considerations it is just those lying between the inland climate and the coastal climate which are of special importance. To these climates must be added that of the Thracian inland. In contrast to the actual inland climates we observe here a general increase in precipitation, a diminution in the temperature range and an increase in humidity. The danger of cloud-bursts increases, the daily rainfall maxima recorded exceed 100 mm. As the zones in question are mostly in country of a hilly nature, frequently wooded, we have to reckon with the increased importance of soil protection.

There are numerous local climatic peculiarities in these transitional zones, conditioned by their morphological structure and their intermediate climatic position. The highest absolute annual variation of temperature hitherto recorded was 71.6° at Bolu, which is situated 700 m. above sea level and only 50 km. from the coast of the Black Sea.

This short review of the climatic conditions and the structure of Anatolia shows that we must encounter many different aspects of the erosion question. As in addition the use made of the land in the different districts is very far from uniform, the problems of erosion are entirely different in the individual districts, and must be discussed separately.

Land Utilization and Erosion in Different Districts.

Black Sea Littoral.

The Black Sea Littoral, with its high rainfall and great differences in altitude governed by the closeness of the mountains to the coast, is particularly liable to erosion. Where dense woodland is still present the soil is protected to a considerable extent. Nevertheless, even in wooded regions deeply cut stream-beds can often be observed after heavy cloud-bursts. But if the ground is deprived of this protection through felling or burning the danger of soil-washing is greatly increased. The steadily diminishing soil cover resulting from erosion affords vegetation less and less opportunity for development, by degrees wild plants can only maintain themselves in cracks and crevices, and on the steep slopes the bare rock is exposed (Fig. 1).

Another danger after deforestation is that of the landslide. The soil is no longer protected by the wood from the rapid penetration of heavy rain, and the tree roots no longer hold it together. The friction of the soil on the rock is reduced by the penetrating water; the soil loses its hold and slides to the valley. An attempt is being made to prevent this kind of destruction through the regularization of woodland management by means of Forest Laws and through Government protection of forests.

Agriculturists everywhere on the Black Sea coasts have to contend with serious soil erosion. Many of the fields, which as a rule are small, lie on the slopes. Often they are so small that they can be tilled only by hand. The principal cultivated plant is maize, which in the eastern part of the country is frequently grown in a mixture with beans. In the west wheat and barley are more important, and in certain districts (Samsun, Trabzon) tobacco is also grown,. That means, therefore, that in spite of the great risk of erosion we find nowhere the cultivation of plants which protect the soil. In just those months which have the heaviest rainfall, namely, in the autumn and winter months, the land, in so far as it is not covered with weeds, is entirely bare.

For the hazel nut cultivation practised in the eastern part of the Black Sea coast, no special records or investigations are available in regard to soil erosion. There is, however, no doubt that the washing of soil here also presents a serious problem.

With the intensification and extension of crop growing in the coastal strips along the Black Sea, the systematic protection of arable land from erosion will have to be one of the most important tasks if the whole of the most valuable soil is not to be destroyed. It will be necessary to prevent the occurrence not only of the greater and more visible destruction, but also the continuous although less perceptible removal of soil matter which leads to the gradual deterioration of the land.

It will not be possible to avoid terracing of the land on steep slopes, but in more favourable situations the cultivation of protective crops must be begun on a large scale. As holdings are very often extremely small and the growing of maize cannot be dispensed with, legumes will have to be sown with the maize. These legumes may be ploughed under in spring as green manure for the cereal, or used as early green fodder. In any case an effort must be made to ensure the presence of a thick, protective plant cover in the autumn and winter.

West and South Coasts.

Entirely different conditions are found on the west and south coasts. Here it is the great coastal plains and the river valleys, often extending far into the land, and their lateral slopes which are of special importance for crop cultivation. In addition to plantations of figs and olives in the west, citrus in the south, and vineyards for the production of currants, the main crop plants are wheat, barley, tobacco, sesame, and cotton, all crops which afford the soil little protection against erosion.

In winter and spring, therefore, a great part of the land is regularly covered with mud, and frequently great quantities of fine earth are washed away. In the spring of 1931 we observed on the edge of the Cilician plain that rainfall of merely medium proportions resulted in a considerable amount of erosion, even in the case of only slightly sloping fields. The effect was especially great because nowhere in the fields was there a crop which could have impeded the rapid flow of the rain-water.

A one-sided extension and intensification of these crops, and especially of cotton growing, would constitute a very great danger to the soil in these districts. It would mean that new slopes, which to-day are to a great extent protected from soil erosion by their growth of natural flora, would have to be brought into cultivation. Further the practices of deep tillage, drill-sowing and careful weed eradication would be introduced. All these operations diminish soil protection and increase the danger of erosion, already much favoured by natural local conditions.

Far-sighted planning for the promotion of agriculture must therefore take into consideration, from the outset, ways and means of protecting the soil and as far as possible conserving its fertility for the future. Tillage and cropping systems must be planned with this object in view. First and foremost, therefore, an effort must be

made to plan and maintain a favourable proportion between crops which prevent the destruction of the soil and those which do not impede erosion. In many cases terracing will have to be employed to prevent the falling of land. These measures are unconditionally necessary, as otherwise there is a risk of fertile land situated in particularly favourable localities becoming within a relatively short time useless for any sort of crop.

Central Anatolia.

Anyone who travels through central Anatolia is astonished at the disastrous results of erosion in every part of this arid region. They are surprisingly marked everywhere, although on account of the difference in the rock and in altitude they vary in their nature. Fig. 2 shows a deeply cut river bed which flows out into the Kizil Irmak. It is dry as early as the beginning of May, when the masses of detritus carried down are all there is to be seen. The downpours of the "kirkikindi" generally bring down again for a short time great masses of water into the river bed.

Fig. 3 shows what was originally a uniform, sloping plain, in which deep gullies have been cut. Near Sivas we saw a valley in which gullies at least 10 m. deep and of similar width had been washed out of the best red earth.

The erosion to be observed will not in the future be produced by normal rainfall, in itself slight. Nor is the water resulting from melting snow of any great importance, as the only heavy snowfall takes place upon the higher mountains. Of much greater effect are the cloud-bursts, especially such as occur during the "kirkikindi." During that period large quantities of water frequently fall within a short time, and have a great effect in producing erosion, even if localized.

On June 9, 1933, we experienced a cloud-burst of this kind on a mountain pass in the vicinity of Ankara. It was characteristic that on the same day not more than 3.5 mm. of rain and a little hail was recorded by the Meteorological Institute only 40 km. away.

A few minutes after the rainstorm had set in the whole mountain slope was intersected by gullies carrying down a liquid loam. Within a short time there arose in the valley a torrent which rushed with enormous force down to the plain. When this emerged into the Ova the bed could no longer hold the masses of water, which then spread over the plain in fan-like formation. The stones and rock detritus carried down were deposited in fan-shaped heaps at the entrance to the valley.

Analysis of a sample of the liquid taken from one of the primary gullies showed that it consisted of 343 grm. dry matter and 861 cc. water per litre. With a specific gravity of 2.47, therefore, 72 mm. rain rushing down under similar conditions would carry off from the slopes a soil layer 1 cm. thick if enough loose material were present. Herein we have not considered the deep erosion which takes place in the larger torrent beds. Thus the effects of single cloud-bursts in the arid region are extraordinarily great. The steppe plant cover is not able to protect the soil, which in consequence of its naturally loose nature is easily removed as detritus.

The mud carried off with the water may be very fertile, as is known in the case of the river Nile. An example on a small scale is furnished by Tosya. Here, in the valley of the Devres, rice is grown. According to the farmers it is not necessary to apply manure, as every year very fertile yellow mud is carried down by the floods from the Cerkes district which they then dam up in the rice fields for the sediment to settle.

As we have shown above, the climate is highly propitious for the weathering of rock. From most of the bare mountain crests pieces of rock, varying in size according to its nature, are broken off in the course of time. These remain as a rule near the locality in which they fell, as the ordinary rainfall does not furnish enough

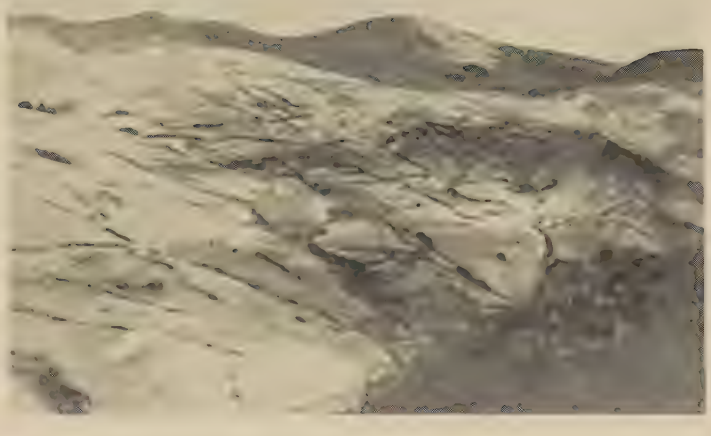


FIG. 1.

Formerly wooded hillside on the Black Sea coast after deforestation.

FIG. 2.

Deeply eroded valley of a tributary of the Kizil Irmak (Halys): only occasionally watered.

FIG. 3.

Much eroded area near Yerköy.

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Fig. 4.

Fan-like arrangement of stone rubbish from a torrential stream caused by a cloud-burst in 1937.

Fig. 5.

Rice valley near Beypazar (Vilayet of Ankara). Half of the valley bottom has been rendered useless for cultivation through stone deposits.

Fig. 6.

Salt precipitation after flooding, 1935. 40 km. from Ankara.

water to move them. But when a violent cloud-burst occurs some of these rocks are washed away, taken into the mountain torrents, and carried down to the valley, where they frequently cause an enormous amount of damage.

In the present year, 1937, we have seen, in the greatest variety of localities in the Vilayets of Ankara and Cankiri, the destruction which has been caused by masses of rock of this nature. In some places the fields were entirely buried under the stones, in others vineyards were threatened, and frequently the fertility of land not yet used for crops was destroyed (Fig. 4). Especially susceptible to damage by torrents carrying down stones is the rice cultivation of the interior. Rice-growing in the uplands is possible only in the deeply cut valleys, which are extremely hot in summer. These valleys are particularly liable to occurrences of the nature described. In many valleys the area of soil available for cultivation has already been reduced to a fraction of the valley bottom, the remainder of the land being covered with a layer of stones (Fig. 5). In some villages we were told that only one generation ago the rice-growing area was double its present size.

The astonishing thing is that the torrents frequently have their source in a very small region and have a short course only. The more remarkable is the tremendous transport of detritus that has taken place.

The systematic control of detritus-bearing torrents of this nature is thus an important item in the soil protection of all those parts of central Anatolia wherein surface constitution and climate favour their formation. This work is of quite especial importance for districts in which areas that might be irrigated are threatened, as for example the rice cultivation valleys and many other valleys also. Thus a village near Ilgaz reported that it lost annually several hectares of its irrigable land from mountain torrents. In another case the farmers tried to carry away the stones which had been washed down on to the land, but with little success in spite of weeks of work. The same amount of work applied to the control of the torrent itself would probably have prevented the catastrophe, or at least mitigated it considerably.

That rainfall torrents may also be dangerous in the formation of deep gullies in agricultural land need not be emphasized. The inauguration of systematic preventive measures of control must take place in this case also.

The risk of dust storms constitutes a further problem of soil conservation in central Anatolia. This becomes particularly urgent as soon as agriculture is reorganized on modern lines. The present form of steppe agriculture, even in districts with frequent storms in the dry period, affords the wind little opportunity for attack. It is true that the Anatolian farmer has from the earliest days been accustomed to an alternation of fallow and cultivation in the arid lands, but he fallows generally in the late spring. In the majority of cases he still uses the old hook-plough, which does not loosen and turn up the ground deeply, but only tears it superficially and then leaves it in relatively thick lumps. Further, in most districts only a part of the steppe is under cultivation, the rest is untouched and is used as pasture. Reorganization on modern lines and an extension of crop cultivation would increase the danger of wind erosion in many districts. The fallow would be broken up in early spring with modern implements and would subsequently be kept free of all weed growth by cultivation. In districts where dust storms occur regularly in summer and in districts where dust spouts are frequent, measures must be taken in advance to meet the danger of wind erosion. In spite of the disadvantages, strip cropping with alternation of fallow and cultivated strips would have to be introduced in order that large areas should not be subject to the influence of the wind.

The systematic protection of soil in central Anatolia thus has its quite special requirements. First, it is necessary to adopt measures of protection against the detritus-bearing torrents that destroy the most valuable land in the valleys; further,

the danger of gully formation in sloping areas must be prevented; and finally the risk of dust storms, increased in some cases by the intensification of arable farming, must be met by alterations in the methods of cropping.

South-Eastern Anatolia.

In south-eastern Anatolia the conditions encouraging soil erosion are similar to those in central Anatolia. With the rare but heavy rainstorms or cloud-bursts there is always the risk of low-lying regions being covered with mud. Here again there is the danger of the rock-carrying torrents in the mountain regions. In the regions bordering on Syria great dust storms occur.

Eastern Anatolia.

Conditions for soil erosion are quite different in eastern Anatolia from those in the regions so far considered. During the long winter the soil lies under a heavy covering of snow for four or five months. With the rapidly rising temperature in spring, the snow thaws relatively rapidly, and considerable quantities of water are released. It is true that on account of the deeply frozen fields they hardly contribute directly to the erosion of the soil, but they are of great importance in increasing the erosive work of the streams and rivers because they produce flooding, which in turn leads to the deposition of silt, of far-reaching importance for the soils of the valley plains.

Where woodlands have been destroyed, great destruction and erosion of the mountain slopes occurs, although mitigated in part by vigorous natural plant growth, which in the less steep localities affords good protection for the land. Many perennial wild legumes are found here.

In spring and summer heavy rainfall also occurs here, and any sloping arable land is exposed to erosion. It is true that through the present methods of land cultivation the danger is greatly reduced. In the first place the fields do not lie in large compact areas on the slope, but are continuously interrupted by strips of natural plant cover, and in the second place protective crops such as *Onobrychis sativa* and lucerne are grown.

Wind erosion is of no importance in eastern Anatolia, as hardly any dry area of important size is without plant growth.

Transitional Areas.

The transitional areas between the inner Anatolian and the coastal climates, to which, as has already been mentioned, inner Thracia should be added, have on the whole considerably higher rainfall than the more inland regions. At the same time the frequency and violence of the cloud-bursts are increased. The soil is correspondingly exposed to erosion to a great degree, especially where sloping land is cultivated. In serious cases the soil surface is completely destroyed and the bare rock emerges; in less serious cases there is a continuous reduction of fertility. In these districts one repeatedly meets farmers who complain that their soil is becoming less and less fertile. Here the consequences of removal of the soil surface in the form of silt are noticeable, and with them the depression in soil productivity. Soil conservation in these regions, where climatic conditions often favour crop cultivation, is therefore an urgent problem.

Chemical Erosion.

In addition to the mechanical forms of soil erosion already discussed, "chemical" erosion, that is, the liberation and removal of soluble substances through the action of water, is of decisive importance for the fertility of the land, even if not so apparent.

In so far as chemical erosion leads to the removal of substances in solution through the rivers to the sea, it indicates a perpetual loss of plant nutrients. Unfortunately no investigations have yet been made which enable one to form an estimate of the approximate extent of a loss so serious for Turkish agriculture. It is, however, obvious that the growing of crops which do not protect the soil may encourage chemical erosion as much as it encourages mechanical erosion, and that the correct distribution of crops and suitable rotation would considerably reduce both forms of erosion in the threatened districts.

The formation of the saline soils may be described as a further effect of chemical erosion, and in conclusion we will briefly discuss this phenomenon. In the arid region the dissolved substances are not carried off, or only partly so, a great part of the salts being retained in the soil solution or in the soil water. With heavy rainfall it is washed into the depressions, where the water evaporates and the salts are precipitated (Fig. 6). In other cases there may be a considerable rise of the soil water in deeper places, so that it is exposed to evaporation directly or through being raised to the surface by capillarity. Here also the formation of saline soils or even the efflorescence of salts on the surface occurs in time. This process may be considerably accelerated by unscientific artificial watering.

The formation of saline soils is a serious danger for crop cultivation in all the arid and semi-arid regions of Turkey, and salt soils are to be encountered in all parts. They are particularly widespread in the Konya depression, which has no drainage outlet and in which the great salt lake is situated. The tendency to accumulate salt in the lower or upper soil surface forms a great hindrance to irrigation, and can make it entirely unprofitable in many districts. This must always be taken into consideration in the artificial application of water, and must be prevented as far as possible by carefully avoiding the use of excessive amounts of water.

Crop cultivation, even without irrigation, may promote the salinization of the soil in the semi-arid districts unless systematic conservation measures are adopted. This appears to us to be the case in the Adana plain, for instance. The exclusive growing of plants which afford the soil no protection encourages chemical erosion as well as mechanical erosion. At the same time the soil water, enriched with salts, rises in the deeper localities of the plain. Thus the conditions arise for a gradual accumulation of salt and therewith for a slow but steady diminution of fertility in these lands of the deeper zones.

One of the tasks to be undertaken in systematic soil conservation is therefore the control of chemical erosion. Herein there must be a diminution of the losses which arise from the leaching and washing away of valuable plant nutrients, and in addition the prevention, as far as possible, of the formation of salt soils. Experience in America has demonstrated the enormous importance of chemical erosion together with slow mechanical erosion. For the last fifty years there has been no increase of yield in that country, in spite of the introduction of modern agricultural technique, soil tillage, manuring, the utilization of better varieties, etc. That is, all such measures can only just maintain the equilibrium of agriculture against the deterioration of the land brought about by erosion. Material improvement can be expected only from the reorganization of cropping for systematic land conservation.

Conclusion.

In summarizing it may be said that the problem of soil erosion in Turkey has many aspects, as natural conditions are diverse. In many districts soil conservation is one of the most urgent tasks to be undertaken for the promotion of field husbandry. Especially subject to erosion are, as we have shown, those districts which are just the most favoured by climate, such as the sea coasts and the transitional zones.

In central Anatolia the fertile valleys in which rice or irrigated crops are grown require especial protection. The measures to be taken are very varied, in accordance with the very different conditions promoting erosion in the various regions. To be successful they must be adapted to the special conditions of each individual district.

The importance to be attached to systematic soil conservation and to the crop cultivation based upon it is shown by the experience of the United States, summarized in the 1937 Yearbook (**6**) as follows : " Mistaken land-use practices in the United States have caused the ruin by erosion of some 50,000,000 acres and seriously damaged 50,000,000 acres more." The destruction of the soil is estimated therewith at approximately twenty million hectares and an equally large area is reported as being seriously damaged, that is, in America double as much land has been ruined, and double as much again has been damaged, as the total area to-day under the plough in Turkey.

In the reconstruction of her agriculture Turkey is in a position to avoid the mistakes which have been made in other countries. She can and she will so arrange the measures to be taken that soil fertility, even in the regions threatened by erosion, shall be maintained for long years to come. Just because the campaign against soil erosion cannot be conducted with any prospect of success by individual farmers, but only by the united efforts of the agricultural population of a district, the same attention being paid to uncultivated land as to that under cultivation, it is a very favourable moment to launch this campaign when the State, in undertaking the improvement of its agriculture, is at the same time undertaking measures for the protection of the soil, and is thus enabled to carry out for whole districts projects in both spheres simultaneously.

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METHODS USED IN SCIENTIFIC PLANT SOCIOLOGY AND IN AGRICULTURAL BOTANICAL GRASSLAND RESEARCH.

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KLAPP (**9**) felt the need for creating a bridge between the study of grassland sociology and agricultural botanical grassland research. The objects of an investigation differ, of course, in pure and applied science. Both fields can proceed on the same lines when the way in which the objects of the research are distinguished is similar. This is, however, not always the case.

In modern plant sociology there are two main tendencies to be distinguished. The School of Braun-Blanquet (**3**) (Montpellier) distinguishes typical combinations of species. In the study of plant communities emphasis is laid on the so-called *qualitative analysis*, which consists in compiling and comparing complete lists of species. The important factors are not only what species are present, but also their number and its relation to the number of genera. If the number of genera is relatively high, it indicates an extreme habitat (Jaccard, **8**). A species list of this type is made up for the whole area of a certain plant community, or for a square of definite size, for example, 100 m.^{2} for grassland. In such a sample area a part of the society is selected and taken as typical. The fundamental unit of vegetation, the association, is characterized by the assembly of species. Under this head are included in the first place those characteristic species which occur only in a definite association, or at least show some preference. Then follow the species with a high degree of presence, which are encountered on many lists. The sociological method of Braun-Blanquet (**2**) is particularly suitable for the taxonomic study of plant communities, but is of less value in cultivated communities, such as well-treated grasslands. As such a cultivation becomes more established, the number of constituent species decreases and the characteristic species of unmanured societies disappear. It may be added that the study of the mass relation between species in such vegetation is only of minor importance for this sociological School. Generally these investigators give little attention to *quantitative analysis*, which applies both to the relative proportion in mass of the species of plants present and to the abundance (density) of the plants and the regularity of their distribution within the plant society.

Good grasslands and quantitative analyses are naturally of the greatest importance in agricultural grassland work. The productivity of the grassland as well as the quality of the crop depend directly on the mass proportion of the species present. It is, therefore, understandable that Klapp, when considering the plant sociology of Braun-Blanquet, is not satisfied. The usual methods of estimation of this School, such as determination of specific percentage area covered, cannot be satisfactory. The swards of our grasslands are generally too dense and consist of a mixture of many species which makes this method difficult and unreliable.

When we consider, however, the other main tendency in plant sociology no gap appears to exist in principle between its viewpoint and that of agricultural botanical grassland research. For many plant sociologists, including several northern investigators, homogeneity and dominance form the basis of distinction between the fundamental units of vegetation. The predominance of certain species is of great importance as it constitutes an indication of their success in the struggle for existence under given circumstances. Of the ideas expressed by this Northern School we agree more particularly with those of Gams (**6, 7**) and Regel (**16**). We make similar distinctions in our scientific sociological and agricultural grassland research. The objects of such research are, therefore, comparable.

In *exact sociographic grassland research* we should obtain as clear an idea as possible of the structure and composition of grassland, regardless of trouble and time. In the years 1924 to 1927 I, in collaboration with some colleagues, studied the low moor meadows in the Dutch polder district, De Krimpenerwaard (**17, 18, 20, 30**). The sociological method used met the requirements of versatility, objectivity and exactness. Lists were compiled of the species in the plots of land and in single societies. The species present were noted within squares of varying dimensions, namely : 100 m.^{2}, 1 m.^{2}, 100 cm.^{2} and 4 cm.^{2} (mosses). The squares of varying size were situated concentrically within each other and those of the same size were spread uniformly over the land. The quantitative analysis was also objective and no estimates were made. Counts were made of the number of rooting shoots of each species within each small sample area and later the dry weight or the volume was determined. This investigation was not confined to the analysis of single societies, but their degree of combining, and therefore the structure of the higher units of vegetation, was also ascertained (**17**).

In *agricultural botanical grassland research* a primary objective should be to obtain practical results as easily and quickly as possible, ascertaining at the same time, of course, that the results are sufficiently reliable. The methods of determining botanical composition will depend also on the aim and object of the investigation and on the circumstances.

The two principal aims of applied botanical grassland research which are to be distinguished but between which no sharp demarcation must be drawn are : (a) the analysis of the cattle food, hay, aftermath and pasture grass ; (b) the knowledge of grassland types in relation to climate, soil, drainage, utilization and treatment. It is evident that the method of analysis also depends on the object of the investigation, for example, whether we are concerned with an extensive area of natural grassland, or with small plots of cultivated grassland such as are common in the Netherlands, or whether the grassland is mown or kept closely grazed. As the moss flora may also be of importance, such cover must be included in the investigation.

Last but not least, the circumstances under which we work, primarily those regarding time and finances, are important in deciding the methods to be followed. Both factors mentioned can, however, be modified to no small extent by organization. At the Government Agricultural Experiment Station, in Groningen, female assistants (not highly paid) analyze grass samples in an objective way and on a large scale under expert guidance, so that the investigators need not have to rely upon estimates through lack of time.

The reliability of the results depends as much on the method of sampling as on the method of analysis. We have rejected the system of typical sample areas applied by Stebler and Schröter (**19**) and in the Netherlands by Kramer (**10**) because this is too subjective. The Experiment Station at Groningen requires good mean values for the field or for the plant community. According to the nature of the method, numerous small samples are taken from all parts of the field, or notes are made regarding many equally distributed small sample areas (de Vries, **26**). If the plot is rectangular we proceed to sample along a diagonal, and then along two or three equidistant lines, each side of the diagonal. The results of objective methods in which weighing or counting is used, or in which the presence only of species is considered, are naturally more reliable than those obtained by estimation methods. If the latter are adopted, we must then reduce the subjective element in them as much as possible. The pure scientific method described briefly in this paper, and used in the exact sociological research in De Krimpenerwaard was a combined method. Taken as a whole, it cannot be considered as suitable for agricultural grassland research as it requires too much work and time. We shall discuss successively the different components of the method employed.

A. Analysis of the mass (dry weight or volume).

Not only in that tendency in plant sociology by which it is assumed that dominance is the fundamental criterion of plant communities, but also in agricultural grassland research must great value be attached to the determination of the proportion in bulk between the species. Thus analysis by dry weight becomes logically of primary importance, because by its application we obtain immediate information regarding the botanical composition of the cattle-food hay, and a certain extent of its quality also. The determination of volume by immersing the herbage in graded cylinders cannot be used in applied research as it requires too much time and the material must be analyzed immediately while still fresh. The analysis of fresh material by weight must also be rejected as the herbage samples dry up particularly during the sorting. Determination of the absolute dry weight is unnecessary, that of the air dry weight being quite sufficient.

Rauwerda (**14, 15**), who first investigated the herbage of meadows in the Dutch province of Friesland by weight analysis, took numerous handfuls from the swath when sampling. The handfuls were placed together in one collective sample. Zijlstra (**31, 32, 33**) improved the method by cutting the standing grass with a spinach knife just before it was ripe for cutting. At first I used frames with an area of 100 cm.^{2} (**27**) in order that in the examination of the herbage of short grazed pastures the same surface was always bared. Since 1933 I have used a sharp borer with a section of 25 cm.^{2} (**25, 26, 32**). With 160 borings per hectare the standard deviation was found to be small (**28**). In the predominant species it was 6 per cent of the average weight percentage of 18 pasture samplings, each consisting of 160 samples. Hundreds of dry weight analyses are made every year at Groningen. The grass samples can be kept sufficiently fresh for about a month at a temperature of just over O°C. Samples of hay have also been completely analyzed for some years past.

Weight analysis has proved to be the best method for determining the influence of external circumstances on the proportion in bulk. This method is to be recommended for botanical examination of the herbage of plots in field experiments and for the study of the influence of weather conditions. The proportion in mass of the different species growing on the same field may, however, vary considerably from time to time, owing to the many uncertain influences and the occurrence of early and late ripening species. The weight analysis is, therefore, less suitable for research on grassland types. Nevertheless it is fairly suitable when the herbage is ripe for cutting, although in this case sampling is limited to a short period, namely, the haymaking time. For the investigation of grassland types another method (see sect. C) may be used, which not only distinguishes the group of species which form a greater part of the bulk when sampling, but also those which are found in many small sampling areas. If the circumstances become more favourable, these species may rapidly take a prominent place. On deeply drained, heavy clay grasslands it was proved that *Poa trivialis* L. constituted 7 per cent of the bulk after a dry summer and 20 per cent after the exceedingly wet summer of the following year (**23, 24**). *Trifolium repens* showed the opposite behaviour. Nevertheless both species, as well as *Lolium perenne* and *Agrostis stolonifera* are typical of this type of grassland, although their productivity varies from time to time. *It is the potentially important and not only the temporarily predominant species during sampling which really show the type of grassland.*

The weight analytical method can be substituted by :

(1) *The method of estimating percentage productivity,* as adopted at Aberystwyth (Davies, **4**). When using this method the laboratory sample is divided into ten subsamples, each of which is allotted ten marks. These marks are divided among the species present according to the estimated proportion by mass of each species. The total results give the percentage productivity immediately. This very rapid method

is most convenient when the vegetation is simple in constitution. Moreover the samples should be in a fresh state and the accuracy of the results depends to a great extent on the peculiar talents and reliability of the analyst.

(2) *The point quadrat method* of Levy (**4, 11, 12**), modified in such a way that the sample is spread out evenly over a table. Each time the herbage is hit by a pin-point a record is made of the species in question.

(3) *The order method* (de Vries, **21, 22**). This method of field estimation not only gives a proper insight into the proportion of different species in the herbage, but also records data regarding the sociability of the species and the homogeneity of the sward, as separate data for the different readings distributed equally over the paddock are obtained. This method is rapid, especially the simple or groups order process in which the grasses, legumes and weeds are considered as a whole. The results are reliable and the subjective element of estimation methods is reduced to a minimum. This is based on the fact that the order of sequence of the chief species or groups can be determined quickly and accurately, a claim which cannot be made for the percentage estimation (on a five or ten division scale) of bulk, frequency (abundance) or area covered. One drawback of the order method, such as employed by me with a frame of 100 cm.^{2}, is that it can be used only in the field and is, therefore, unsuitable for extensive routine work in the laboratory. Moreover, the complete order method can be applied only by experts.

Apart from productivity, the area covered by the separate species is sometimes interesting, especially in the case of sports grounds and other closely grazed or shortly mown swards. In this connexion we prefer the point quadrat method of Levy (**11**), which is an objective method, to the percentage area methods introduced by Weber (**5**) and Armstrong (**1**). A disadvantage of these estimation methods is that their results always depend to a great extent on the capacity for accurate estimation and the training of the investigator.

B. The abundance determination.

This method, also called the *percentage frequency method*, by which we obtain a detailed numerical count of tillers of different species, gives no good idea of the mass proportion of the different species, because the tillers of several species may differ greatly in bulk. Also for the study of grassland types this method in itself is not efficacious. It appears to us that the abundance (density) does not vary much less than the mass proportion (**27**) during the course of the year. Moreover an exact density determination is much more laborious than a weight analysis.

C. The sociological or specific frequency method.

The results of the frequency method, in which only the species present in regularly distributed sample areas of the same size are noted, vary much less from time to time than the results of the weight analysis and density determination. The larger the sample areas the larger is the group of species which are generally present (de Vries, **25**), and the less is the difference in frequency of the separate species, when sampling is done at different intervals. *If one uses sample areas of 25 cm.^{2} for the specific frequency method, even then the periodic differences are much smaller than those obtained by determining the mass or abundance* (**27**). *The use of the small size has the advantage that we can raise the potentially important species above the other species. The 25 cm.^{2} frequency method seems to us, therefore, to be very suitable for research on grassland types.* For this purpose it is unimportant that the arrangement of the very frequent species does not correspond to their order in weight. In connexion with the determination of grassland types a further advantage is that the frequency of one species does not depend upon others, whereas weight percentages are relative. Fin-

ally, the frequency method indicates the regularity or irregularity of the distribution of different species over the field.

Frequency determinations can be made quite easily when using sample plots of 25 cm.^{2}. For taking the samples we use the borer which is used for the weight analytical pasture method, or we take a small scoop, 5 cm. wide, and put every boring or sample into a separate bag. The analysis is carried out in the laboratory by female assistants and the selection takes about the same time as the weight analysis of a common collective sample.

For a good determination of grassland types the 25 cm.^{2} specific frequency method can be combined with the order method (**29**). Notes are made not only of the species present but it is also estimated which of them occupy first, second or third place. This requires only a little more time. In this way we obtain both a better understanding of the mass proportion and a good idea of the sociological behaviour of the separate species. Diagrams may be drawn for any species in any sampled field to indicate the species which are uniformly dispersed (more or less dense), the tuft formers, and the species of local occurrence (**26**). Moreover this combined method effectively indicates the divergent places in the sward. In this way the order method is best suited to the extensive analysis in the laboratory.

D. Compilation of the complete list of species.

Finally qualitative analysis, that is, the noting of all species which are found by careful observation, is not without some agricultural value. In the first place it is of practical interest to note whether poisonous or noxious species occur on the grassland. Even if some species are not numerous they give useful indications regarding the characters of the habitat, which are of great importance to the grass growth. Finally the presence of definite species can provide data concerning the origin and history of the grassland being studied.

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MODERN CONCEPTS OF GRASSLAND IMPROVEMENT.*

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THE agronomic approach to the study of pasture problems may be made from three major standpoints, as follows: (a) a study of the botanical composition of a particular piece of pasture as it stands; (b) the status of soil fertility in relation to the surface vegetation, and (c) the influence of the biotic factor which includes in addition to the direct influence of man and his grazing animals, the effect of other biological forms—bacteria, insects producing disease and vermin life.

BOTANICAL COMPOSITION.

The usual components of grassland are divisible into three major groups, namely, grasses (members of the Gramineae), clovers (members of the Leguminosae) and weeds (plants belonging to families other than the Gramineae and Leguminosae). In the grasslands of Britain, for example, many members of the Compositae are prominent components—note the genera *Bellis*, *Crepis*, *Hypochoeris*, *Leontodon*, *Carduus*. A good deal of work has already been accomplished in connexion with the analysis of the grasses and clovers. By analysis and synthesis plant breeders have built up new strains, some of which are proving superior in economic value to the natural mixed material. Many of these new strains are already being put to commercial use. Less is known with regard to the so-called "weed flora" of our grasslands, but the indications are that many plants included in this group have particular value. Fagan and Watkins (**2**) have shown, for example, that the leafage of many grassland weeds is particularly rich in minerals and protein. There are also indications that plants such as ribgrass (*Plantago lanceolata*) can under certain conditions provide an amount of out-of-season green feed (in early spring) quite appreciably in excess of that from many grasses.

It is clear that different species vary in their economic usefulness as pasture plants, but, equally so, contrasting strains within these species have their own sphere of greatest utilitarian value. It is appropriate therefore to consider some of the factors which determine the agricultural value of any given set of pasture plants growing under any particular set of soil and climatic conditions. These factors may be classified as follows:—

Yield of nutrients, which takes into account not only total yield, but also the mineral content, the proportion of leaf to stem and content of protein, carbohydrate and oils. The yields may be expressed on the basis of starch equivalents or upon some other standardized value such as the "fodder unit" of Continental workers.

Seasonal productivity, including reaction to temporarily adverse weather conditions whether of normal occurrence or whether abnormal in nature. Obviously a plant that shows ability for high production and has a long season of growth is more valuable to the grazier than one of equal production capacity, but which has a short growing season. Proper utilization of the grass crop under pasture conditions becomes increasingly difficult with grasslands that make abundant mid-season growth, but are dormant both prior and subsequent to the main seasonal flush of growth. Perennial ryegrass is one of the most useful pasture plants in Britain, and

*This article is the substance of a paper read at the annual meeting of the British Association for the Advancement of Science at Nottingham, September, 1937, to a joint meeting of Sections K and M.

the high value placed upon it is quite appreciably due to the fact that it has a very long season of growth and in addition remains remarkably winter green. Young growing grass of this nature is usually highly palatable and provides first class animal food.

In sharp contrast to perennial ryegrass is flying bent (*Molinia caerulea*) ; this species yields in the aggregate a fairly heavy crop of leafy herbage, but is almost completely dormant for nearly ten months of the year and has therefore a grazing season not exceeding a few weeks in midsummer. On the score of seasonal productivity, ryegrass would receive high marks, whereas flying bent would receive a minimum only.

Winter greenness, the ability to maintain green and nutritious herbage which remains palatable when grown in autumn and consumed either in winter or in early spring. Some of the current research at the Welsh Plant Breeding Station shows that autumn-grown grass will conserve *in situ* and, if winter green strains are employed, will provide highly nutritious and very palatable herbage at a time when growth is normally at a standstill. A temporary ley in its second harvest year when enclosed in July produced herbage which in midwinter had a crude protein figure of 14.3 per cent, while comparable plots enclosed as late as November give a corresponding figure of 23.9 per cent crude protein (**5**).

Persistency. Persistency by vegetative means is a highly desirable character in a pasture plant. This is particularly true in temperate regions of high rainfall, but even in sub-arid climates where the annual pasture plant plays a valuable role in pastures, suitable perennial plants have many added advantages over annual or short-lived species. Thus the perennial is able to take immediate advantage of seasonal rains, whereas the annual, having passed through drought as seed, does not become of grazing value until some weeks later after germination and re-establishment of the seed.

In Britain the ordinary commercial strains of our chief grassland species are relatively short-lived ; the new strains produced at Aberystwyth have been selected because of their attributes of persistency among other valuable characters. If seeds mixtures composed of non-persistent strains of grasses and clovers are sown, little or nothing remains of that sowing after the first year or two, and the land is colonized by inferior pasture plants, including *Agrostis*, Yorkshire fog (*Holcus lanatus*) and various weeds.

Palatability. Different species of pasture plants and to a less marked extent the various strains within these species show different degrees of palatability. Obviously the more palatable the plant, other things being equal, the greater will its grazing value be.

Accessibility, the ease with which the animal can graze the plant. Prostrate plants adhering closely to the ground are less accessible than plants of erect growth.

Aggressiveness and competitive ability. Aggressiveness under pasture conditions is a desirable attribute if there is no undue tendency to crowd out other plants which are themselves valuable or essential ingredients in the pasture. Competitive ability of plants subjected to grazing conditions will be largely determined by the grazing management. Thus under severe hard grazing, flatweeds, wild white clover and *Agrostis* will each be aggressive whereas under a very lenient system of grazing, cocksfoot, Yorkshire fog, tall fescue and other coarse growing grasses will be the aggressors.

Power of recovery after defoliation. The valuable pasture plant is that which can recover most rapidly and become of almost immediate grazing value after each successive period of defoliation. Such power of recovery is of course closely linked with aggressiveness in normal grasslands.

Seeding ability. It is important that herbage plants dealt with in commercial seed production should produce abundant seed of good quality and that the seed crop should ripen uniformly. Compare in this respect ryegrass or cocksfoot, which normally produce good crops of uniformly ripening seed, with meadow foxtail and *Phalaris tuberosa*, the seed crops of which are most irregular in ripening.

Freedom from disease. Disease resistant strains (and species) are obviously more valuable than susceptible strains. Perhaps the grass diseases of greatest significance on pasture lands are the rusts (*Puccinia*, etc.), ergot and in some instances *Epichloe*.

Strain. The work of the Welsh Plant Breeding Station at Aberystwyth has laid stress upon the significance of strain in herbage plants particularly in relation to the production of high class temporary leys and semi-permanent grasslands. These new strains have been subjected to rigorous tests in seed mixture trials laid out on a range of different soil types and under sharply contrasting systems of pasture management. The majority of, if not all, grasses and clovers show wide phenotypical variation, which provides the starting point in plant breeding. At the one extreme are plants that have few tillers and produce stem shoots rather than leaf—plants that usually flower early in the season. Such forms are usually short-lived and may under extreme pasture conditions incline towards the purely annual type. For conditions in Britain they are of low pasture value and play only a minor and transient part in the production of high class leys. Even under the semi-arid conditions characteristic of the belts of Mediterranean climate in both the southern and northern hemispheres, these stemmy, short-lived types among the perennial species of herbage plants are not the optimum forms for use in pastures. They are here proving to be inferior to the leafy high-production types to be found among the purely annual species.

Thus under certain Australian conditions Wimmera ryegrass, an annual, is of greater value than perennial ryegrass, while forms of subterranean clover will supplant white clover under more arid conditions. In another direction leafy, dense-crowned forms of Italian ryegrass are of greater value in Britain than are any of the stemmy, open-crowned non-persistent forms of ordinary perennial ryegrass. It is therefore apparent that the phenotype represented by this latter form has little or no place in the development of high class grasslands. Whether one is thinking in terms of annual or of perennial species, the plants of greatest economic value are to be found among the dense-crowned and leafy phenotypes. It is these forms that in the aggregate will produce high-grade grasslands.

In special circumstances some of the stemmy types within a species may have intrinsic value where early flowering is required. An example is furnished by early flowering forms of subterranean clover in parts of Australia where, under conditions of extreme aridity, earliness in flowering is an attribute necessary in order that the plant will set seed before the summer drought. Even so, it is the dense and leafy strains among these early-flowering forms that prove the most valuable (Adams **1**).

Soil Fertility.

The herbage cover growing on land that has been down to pasture for a long term of years is probably the best measure we yet have of the status of the soil fertility of that land. In this connexion it is possible to group different species (and the same is probably true of strains within a species) according to their demands upon the soil. Thus perennial ryegrass requires fertile conditions for optimum growth whereas bent (*Agrostis tenuis*) will tolerate poorer conditions, while sheep's fescue (*Festuca ovina*), velvet bent (*Agrostis canina*), hair grass (*Deschampsia flexuosa*) and *Nardus* provide examples of grasses which can thrive upon soils of yet lower fertility.

From the agronomic point of view a poor soil in its unimproved state will carry naturally an inferior herbage, often one that is deficient in one or more ingredients of animal food. The problem of herbage improvement therefore is also one that has necessarily to be connected with improvement of the soil and whereby the status of soil fertility can be changed in order that a better class of herbage can be maintained. The so-called unimproved pastures growing on phosphate deficient soils almost always lack clover and the keynote of grassland (and also of soil) improvement is the introduction of an efficient legume. This fact is to be regarded as one of the basic principles in grassland improvement throughout the world. In Britain we are fortunate in having an efficient leguminous pasture plant in *Trifolium repens*. The same is true of New Zealand whereas Southern Australia relies similarly upon *Trifolium subterraneum* ; tropical and sub-tropical areas may have to rely upon species of *Medicago, Stylosanthes, Desmodium, Lespedeza* and other genera. The appropriate species will differ from place to place but it is already clear that, to be properly efficient in promoting the improvement of both herbage and the soil, the pasture legume must be essentially herbaceous, edible and palatable ; it should be reasonably aggressive and show ability to spread under conditions of frequent defoliation.

White clover is our most valuable pasture legume in Britain and its introduction into a previously non-leguminous sward tends automatically to improve that sward. The leafage of white clover is itself rich in protein and lime when compared with most grasses, but the secondary effect of the clover in promoting better health and greater vigour in the herbage as a whole is probably of even greater agricultural significance. Not only is the quality of the herbage improved, but there is an associated soil change. For example, on many of our hill soils it has been frequently noticed that the fibrous matt associated with the unimproved (non-leguminous) hill pasture becomes wholly decomposed and structureless, following the establishment of wild white clover in the unploughed sward. It is significant to note that only where the clover is thriving and after it has become really abundant does such a soil change take place.

The practical problem of grassland improvement resolves itself into two parts. Starting with non-clover pastures such as we find in the uplands the first stage is to make clover-dominant swards. After the period of clover dominance, the second phase in improvement is to introduce appropriate species and strains of high-producing grasses while at the same time maintaining the clover as sub-dominant to the better grasses. The phases are therefore :—

Inferior herbage composed of low-producing plants tolerating poor soils (no clovers).	Clover dominance with grasses tolerating low to medium fertility conditions.	Dominance of high-producing grasses such as ryegrass or cocksfoot, with wild white clover as sub-dominant.

Adequate dressings of phosphatic manures are almost invariably an essential preliminary to the successful establishment of clover on poor swards whereas the high-production pastures of the final phase make heavy demands upon the soil nitrogen. We have probably not yet found the proper form of nitrogenous dressing for pastures of this type ; the nitrogenous residues derived from stock excreta (both urinal and solid) dropped directly on to the pastures seem to have a far more beneficial reaction upon grasslands than have the usual inorganic forms of nitrogen.

The importance of stock manure in relation to pasture yields is shown by the following data drawn from an Aberystwyth experiment (E.155).

Yield of air-dried grass in lb. per acre (=one month's growth cut 29.6.36.)

Plot.	Treatment.	Relative yield (plot J1=100)	
J1.	night grazing only, for 3 consecutive years 1934-36, thus receiving excess of stock manure.	100	1,677
L1.	day grazing only, over same period—depleted of fertility	18	296
J5.	night grazing as J1. but only for April-July each year	67	1,122
L5.	day grazing as L1. but only for April-July each year	41	693

In the ordinary way the plots were grazed fortnightly but whereas plots J1 and L1 were so grazed throughout the grazing season, plots J5 and L5 were afforded a complete rest during the autumn months in each year (1934-36). Plots J1 and L1 receive similar treatment with the exception that the former is gaining fertility (through being grazed at night and therefore receiving additional stock droppings) whereas the latter is losing fertility (through being grazed during the day). After only three years of such management the yield on J1 is five or more times as great as L1 while the yield on J5 (night grazing with long autumn rest period) is only two-thirds that obtained from J1.

Data such as these impress the significance of intensive stocking in relation to pasture yields and suggest that the animal properly employed will appreciably help to make the pasture by promoting an increase in soil fertility, this in turn being automatically reflected in greater pasture output.

It is often said that increasing the concentration of stock on pastures tends to increase animal disease by a multiplication of parasitic organisms. If this be so there lies here a most fruitful line for veterinarian research. Much of the trouble can however be overcome by agronomic methods and particularly by an extension of the use of high class temporary leys designed for periods of from 2 to 6 years and to be reploughed before they are 10 years old. Under a proper system of temporary ley farming the fertility built up by the grazing animal can be cashed out by arable crops or alternatively the land may be ploughed out to be resown directly to grass without the use of a nurse crop. There is little doubt that looked upon purely from the grassland point of view first class pasturage of high output can be maintained indefinitely under a proper system of ploughing and reseeding.

Management of Grassland.

It is now recognized that the grasslands of this country are largely maintained as such under the influence of the grazing animal. Were the latter eliminated our grasslands would revert to scrub and ultimately to forest. Such reversion would take place by well ordered stages in ecological succession,—fern, thicket, scrub, low forest and high forest. The changes that take place in our grasslands are equally marked, but perhaps less obvious. Thus a ryegrass and white clover pasture if left entirely unstocked will gradually give way to types dominated by such grasses as cocksfoot, tall oat, fog, fescues, *Agrostis* or tussock (*Deschampsia caespitosa*). These associations are in fact the precursors of scrub associations.

Our pastures represent an aggregation of different species each making its own particular demands upon the habitat, each reacting differently to the defoliation and treading of animals and each having an influence upon the other constituents with which it is growing in the sward. In fact a pasture may be said to consist of a number of different crops growing together and it is fundamental that we should regard each

sward constituent as a crop in itself. These crops have their own optimal requirements, and any change in the management of the pasture as a whole will react differentially upon the individual components. Some will benefit from the change (and these may even become aggressive) while others may be depressed.

In a mixed pasture of this nature very light grazing will benefit the taller and coarser grasses and the shade-enduring weeds, while close and continuous grazing will favour clover as well as flatweeds. Intermediate forms of grazing will favour specific groups of plants in direct relation to the intensity and frequency of the grazing. It therefore becomes apparent that given the requisite knowledge with regard to the particular demands of any given species or set of species, we can direct our grazing management so as to favour a particular grassland association. Any system of rotational grazing should be based upon such knowledge and should aim at maintaining the particular herbage complex desired.

From the economic point of view the pasture complex which will maintain the largest output of meat or milk is that on which perennial ryegrass and wild white clover are dominant and sub-dominant respectively. The best dairy pastures of Cheshire, and the fatting pastures of the Midlands and other districts are predominantly composed of ryegrass and white clover. The superiority of temporary leys consisting of these two species has been demonstrated by Iorwerth Jones at Aberystwyth (**3**) where leafy ryegrass with white clover has considerably outyielded other mixtures. The output from the ryegrass—white clover plots compared favourably with the average yields of first class permanent pastures although these trials were conducted on relatively poor soils in Cardiganshire. The results are in accord with general findings and are a striking commentary not only upon the value of ryegrass and white clover, but on the use of the temporary ley as opposed to long term permanent grass.

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REVIEWS

ASSOCIATED GROWTH OF HERBAGE PLANTS.

[Reviewer : M. Hall.]

THIS publication* consists of a progress report of co-operative investigations made initially by the Waite Agricultural Research Institute, the Carnegie Corporation of New York, the Council for Scientific and Industrial Research and the Empire Marketing Board. The work is now being continued solely by the Waite Institute and the Council.

Following results obtained by Trumble and Davies (*Herb. Abstr.* 4. 240. 1934) the hypothesis was formed that non-legumes might be capable of deriving nitrogen from associated legumes at a stage considerably prior to nodule breakdown. Also considering the work of Richardson, Trumble and Shapter (*Herb. Abstr.* 1. 73-4. 1931 and ibid. 3. 34-5. 1933), who showed that quantities of soluble nutrient material were transferred in the case of Wimmera ryegrass and *Phalaris tuberosa* from the herbage to roots after the flowering stage and that, in the case of potash, the nutrient could be lost by excretion to the soil whilst the root system was still actively functioning, it was decided to investigate the question of associated growth in pot cultures. Data from the experiments show that when *Trifolium subterraneum* and *Medicago* in association with *Phalaris tuberosa* and Wimmera ryegrass are grown and harvested together under normal winter-growing conditions at Adelaide, there is no evidence that grasses derive N from associated legumes during the vegetative phases of development in the year of planting. Additional evidence regarding plants grown in early summer shows that ryegrass grown in association with lucerne and also with *Trifolium fragiferum* has an increased content of percentage N, which increase is significant in the association with strawberry clover. The conditions of this test differ from those of the other pot cultures in that the experiment was conducted after completion of the normal growing season and therefore under conditions involving higher temperatures in the early stages of growth, greater variations in soil moisture content and lengthened days. There are thus two groups of factors to be considered : (1) those under which annual legumes and lucerne are grown during the normal winter season, and (2) those under which perennial legumes, including lucerne, are grown with artificial watering in early summer following the end of the normal rainfall period. Under (1) it appears that the chief gains made by winter grasses and other non-legumes are from the N accumulated in the soil as a

*AUSTRALIA, Council for Scientific and Industrial Research. Bull. No. 105. Investigations on the associated growth of herbage plants.

1. On the nitrogen accretion of pasture grasses when grown in association with legumes. *By H. C. Trumble* and *T. H. Strong.* pp. 11-24.
2. The influence of nitrogen and phosphorus treatment on the yield and chemical composition of Wimmera ryegrass and subterranean clover, grown separately and in association. *By H. C. Trumble and R. E. Shapter.* pp. 25-36.
3. The yield and nitrogen content of a perennial grass (*Phalaris tuberosa*) when grown in association with annual legumes. *By H. C. Trumble and R. E. Shapter.* pp. 37-40. Melbourne, 1937.

result of root and/or nodule breakdown and the return of N from ingested leguminous herbage. This has important bearing for pasture development on the low nitrogen podsolic and heath soils of South Australia. There should be legume dominance in the early phase with grasses in quantities only sufficient to provide a nucleus for establishment in the second and subsequent seasons. The practical application of item (2) is very limited for South Australia. The nitrogen derived by grasses from associated growth may be governed by type of legume employed and climatic conditions.

The possible effects of variations in the physical environment on legume excretions are considered, together with the significance of the species chosen, rhizobial strain employed, the possible role of a lytic principle and the biological population of the sand cultures.

Under conditions of the experiments reported in the second paper of the bulletin, dry matter yield of Wimmera ryegrass was significantly increased both by phosphorus and N, but to a greater extent by N than by P. For complete development of this plant both nutrients are required in liberal quantities. Further, the response to nitrogen increases as the phosphorus level is raised.

Yield of *T. subterraneum* was significantly increased by P, but not by N, and the increase due to phosphate was much greater, at all levels of N, in the clover than in the grass. Clover yield was not significantly affected by application to the pots of 0.50 grm. N or by 1.00 grm. N, and 2.00 grm. N resulted in lower yield than was obtained by no N treatment. Yield of the mixture was definitely increased by phosphorus at all levels of nitrogen, and is attributable to phosphate stimulating clover development under N-deficient conditions and in stimulating the grass where N was in excess. Nitrogen effect was dependent on phosphate level.

Analysis of individual grass and clover yields showed that grass responded similarly in mixtures as in pure cultures except when a high N dressing was added under conditions of phosphorus deficiency. Thus the grass failed to respond to increased N when grown with clover, although it responded when grown alone. Analysis of individual clover yields showed that clover in the mixtures was depressed by all levels of N, and this depression was due to increased activity of the grass.

A tabulation records the mean dry matter yield of Wimmera ryegrass and *T. subterraneum* when grown alone and compared with that of an association of the two species with varying dressings of phosphorus and nitrogen. Comparison of the general means for all nutrient treatments shows that the mixture yielded a significant increase of 5.15 per cent more herbage above the yield of pure grass and pure grass yield was slightly more than double that for pure clover. This higher yield of the mixture is due to ability of the mixture to prevent (by means of clover content) a reduction in grass yield as a result of lowered N supply. This fact justifies the use of the mixture (in preference to pure grass despite a slightly lower yield under some treatments) particularly for permanent pasture.

Further tabulated data are recorded, each of which tests are under varying dressings of phosphorus and nitrogen. The tables include mean dry matter yields of Wimmera ryegrass grown alone and in association with subterranean clover (and of subterranean clover grown alone and in association with Wimmera ryegrass) ; percentage, yield and ratio of nitrogen and phosphoric acid in the two species, grown alone, in mixture and association.

" The main practical conclusions to be drawn are that under conditions of low available nitrogen and phosphorus, such as occur in the podsolized soils of southern Australia, the greatest increases in production are likely to be obtained by the use of suitably inoculated legumes, with liberal dressings of soluble phosphate. This will also lead to the most rapid nitrogen accretion. As nitrogen enrichment proceeds,

non-legumes will tend to become prominent. Where the available nitrogen level is sufficiently high, a purely gramineous pasture, in the case of a grass-clover mixture, will tend to occur and this will lead to the most efficient utilization of the available nitrogen supply. It is probable that, within limits, the relative quantities of grass and clover present at any growth stage will tend to indicate the available nitrogen content of the soil, provided phosphate is not limiting. This is made possible by the superior competitive effect of grass, which tends to suppress clover as the nitrogen level rises."

The third paper in this group records evidence regarding the extent to which associate grasses are able to derive N from *Medicago denticulata* and *Trifolium subterraneum*, which legumes are the principal ones for pasture improvement in southern Australia.

Phalaris tuberosa is characterized by an extended growth period and it may be able to derive N from associated annual legumes after the completion of their development. Experiments show that the grass is able to derive considerable quantities of N as a result of decomposition of the root systems of each legume shortly after harvest. In the case of *M. denticulata*, harvested eight weeks before the grass, the additional nitrogen was entirely expended in increased growth, percentage N remaining much the same. With *T. subterraneum*, harvested only three weeks before the grass, percentage N in the grass was raised from 0.82 to 3.00.

Evidence is also obtained that N accumulation is greater in subterranean clover than in burr trefoil; thus soil enrichment will in general occur more rapidly with the former. The greater portion of the nitrogen accumulated by these two legumes was located in the leaves, stems and developing fruits. Only 11 per cent of the total N gained was present in the roots and sand of burr trefoil and 25 per cent in the case of subterranean clover. The importance of the extent to which a leguminous crop is grazed or directly incorporated in the ground by mechanical means for nitrogen enrichment of the soil is stressed. The presence of grass in leguminous crops or pastures used for nitrogen enrichment of poor soils will tend to reduce such accretion in proportion to the amount of grass present.

THE SPECIES CONCEPT AS AN ECOLOGIC-GEOGRAPHIC SYSTEM.*

[Reviewer: J. W. Gregor.]

As a result of recent eco-genetical research renewed interest is being taken in the subject of taxonomy. In view of the influence that this taxonomic revival is having on the critical study and classification of the potential sources of plant breeding material throughout the world, and even on the methods of plant breeding, the ideas and taxonomic treatments of the new school of "experimental taxonomists" deserve close scrutiny.

In the important paper under review Sinskaja expresses her opinions on points of fundamental interest to all taxonomists. It is only by the analyses and the determination of the relationships of opinions such as those presented in that paper and elsewhere by other authors, that the hope of ultimate agreement in respect of a suitable terminology can be entertained.

Sinskaja's conception of a species is that of a system of ecotypes. If a range of forms has not broken away from a common system and has not formed within itself

*Sinskaja, E. N. [On species formation in lucerne and in other plants.] 73rd Suppl. *Trudy prikl. Bot., Genet. i Selekcii.* pp. 125. [English summary, 105-24.] 1935.

[A few copies of a translation of this article are available on loan from the Herbage Bureau.]

any system of ecotypes, that range cannot be regarded as an independent species. If, on the other hand, a population, though closely bordering upon a related system, has formed independently a complex system of ecotypes which show a regularity, e.g. zonal, in distribution and does not form a direct combination of the ecotypes of another related system, this population is an independent species.

Sinskaja's taxonomic treatment of these species-populations bears a closer resemblance to the system of classification proposed by Turesson in 1922, than to that of any other author, particularly as regards the terminology employed. It is however just the fact that these two treatments are somewhat similar, though certainly not identical, that renders a critical review unnecessary at the present time.

The units adopted by Sinskaja are as follows :—

1. *Coenospecies*, the components of which are capable of exchanging genes directly or indirectly.
2. (a) *Ecospecies*, systems within the coenospecies which have developed in accordance with ecological differentiation.
   (b) *Geospecies*, systems wherein geographical separation from other related systems has left its mark.
3. (a) *Climatype*, reserved for populations exhibiting characters closely connected with climatic conditions.
   (b) *Geoecotype*, reserved for populations which exhibit *important* characters that cannot be distinguished as being of either ecological or geographical significance.
4. *Ecotype*, units *presumably* differentiated in response to *local* environmental conditions.

Of these six terms the *geospecies* and *climatype* owe their origin to Sinskaja, of the remaining four the coenospecies (Turesson 1922) and ecotype (Turesson 1922) are employed in their original sense, but the terms *ecospecies* (Turesson 1922) and *geoecotype* (Gregor 1931) are used in a sense other than that originally proposed by their authors.

From the examples given in the text it is clear that the ecospecies of Sinskaja are differentiated on ecological-morphological data instead of, as Turesson intended, on the basis of sterility and viability. For example, Sinskaja mentions that *Brassica campestris*, *B. rapa*, *B. Chinensis*, *B. pekinensis*, *B. nipposinica* and *B. glauca* "readily give fully fertile hybrids between one another" yet she designates *B. campestris* an ecospecies, but *B. glauca* a geospecies. The use of the terms ecospecies and geospecies in the sense of Sinskaja might under certain circumstances be confusing, as, for example, in a group where ecological and geographical influences have equally played their part. Such a unit could not be referred to as a geoecotype (in the sense of Sinskaja) without losing taxonomic status. If, on the other hand, the ecospecies were to retain its original meaning, then the unit (whatever the combined effect of ecological and geographical factors) would be exempt from such confusion. Any formation of distinctive ecological or geographical attributes of the ecospecies could then receive appropriate recognition by recording them as eco- or geo-phases of the ecospecies. By this means Nature's units as they exist at the present time would be recorded without recourse to speculation as to their origin. This change in the meaning of the ecospecies has also had minor repercussions on the coenospecies in as much as Sinskaja has found it necessary to create three subordinate categories of the coenospecies in order to express the different degrees of compatibility within her *Brassica* coenospecies.

Of the same taxonomic status as the climatype in Sinskaja's scheme is the *geoecotype*, a term originally proposed (Gregor 1931) to cover local units differentiated

independently of environmental conditions. While the ecotype (Turesson 1922) is accepted by Sinskaja as an appropriate unit for recording the existence of initial *ecological* differentiation, she does not think it necessary to accord equivalent taxonomic status to units which may in fact represent the initial stages in the differentiation of her geospecies. Moreover, the need for some such unit as the geoecotype (as originally defined) becomes perhaps more evident when dealing with the classification of plant breeders' races of cultivated crops, units consciously selected on the bases of *economically useful* characteristics.

DISTRIBUTION OF POA SUPINA IN SCANDINAVIA.*

[Reviewer: R. Peter Jones]

Two years ago, the author reported *Poa supina* Schrad. as a new member of the Swedish flora (Nannfeldt, *Herb. Abstr.* 5. 220. 1935). As it had been possible to pick out a large number of specimens of this species and its hybrid with *P. annua* L. (new to science) from the material of the last-mentioned species in public herbaria, it was predicted that *P. supina* would be found to be "not too rare in large areas in Sweden." The extensive material both of *P. supina* and the hybrid sent to the author indicates clearly that this species is general in large tracts of its area of distribution.

Since the article referred to was written, the author has examined the public herbaria in the other Scandinavian countries, and corresponded with a number of botanists. He has not seen specimens of the species from Denmark or Finland; there is only one collection from Norway, which was found by M. N. Blytt nearly a hundred years ago. The plant's general occurrence in Jämtland up to the northern boundary suggests that it will prove to have a wide distribution, at least in Tröndelag.

Distribution of the species hitherto known in Scandinavia is shown by means of a map. This is of course not detailed, but the irregular exploration of the country is very noticeable. No general conclusions can, however, be drawn from the map. It is probable that the species is absent from the most northerly provinces. In any case its frequency there cannot approximate to that in Jämtland, as it has been sought for in vain in Lappland and the most northerly coastal districts by various botanists familiar with its appearance and ecology in more southerly areas. In Jämtland and Uppland it can without exaggeration be characterized as common (at least in large areas of the provinces). It would appear to have the same frequency in Gästrikland and south Dalarna, where it is very common. In south Sweden on the other hand it seems to be more rare and more irregular in its distribution. Certainly the paucity of the finds proves little, as this area has not been explored as thoroughly as Jämtland and Uppland, and Skårman has found it in a series of localities in a west Västergötland district investigated by him. On the other hand the author has been informed by botanists familiar with the species that they have not succeeded in finding it in certain areas. Thus Almquist reports that he looked for it in vain in the Eskilstuna district and in Norrland between Västervik and Gamleby.

Poa supina obviously prefers damp and somewhat shaded ground. Damp forest paths afford it the best conditions for luxuriant growth, but it is also met with frequently in damp pastures, lawns, meadows and on strands. Its dense sward is very resistant to trampling.

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*Naanfeldt, J. A. On *Poa supina* utbredning i Norden. [On the distribution of *Poa supina* in Scandinavia.] *Bot. Notiser* 1937. 258-65.

A biological character which distinguishes it sharply from *P. annua* should be mentioned here, as it is of great importance in searching for the species in nature, namely, its restricted flowering period. *P. annua*, as is known, flowers almost the whole year round except during the very coldest time. *P. supina* on the contrary has—like, for example, *P. pratensis*—a short, restricted flowering period which occurs at the end of the spring and the beginning of the early part of the summer, in the Upsala district from the end of May to the middle of June. All the stems flower approximately simultaneously; the fruits ripen rapidly and are disseminated, after which the stems wither. Later the plant is hardly determinable, because its non-stem-bearing sward cannot with certainty be distinguished from "perennializing" *P. annua* or from the hybrid. A cytological investigation would decide the matter, as the somatic chromosome number in *P. supina* is 14, in *P. annua* 28 and in the hybrid 21 (Nannfeldt, *Herb. Abstr.* 7. No. 4. 1937), but this method of determination is hardly suitable for floristic purposes.

A list of new habitats of *Poa supina* is appended.

CONFERENCES

BRAZIL, 1936.

A report on the activities of the First Conference of Brazilian Phytopathologists is presented in a special number of *Rodriguesia*, Vol. 2. The report, which is dated 1936, but actually appeared in 1937, contains thirty articles (pp. 366, pls.) ; of these some are recorded in *Herb. Abstr.*, March, 1938. The Conference was held in January, 1936, with a membership of fifty-three, under the patronage of the Minister for Agriculture, Dr. Odilon Braga, and the presidency of Dr. Agesilau Bitancourt.—G.M.R.

CZECHOSLOVAKIA, 1937.

The 34th meeting of the Forage Crop Commission was held in Prague (Praha) in May, 1937. Included on the programme were the preparation of a list of drought resistant varieties of forage crops and the establishment of a special station for drought problems. M. Maloch read a report on forest-pasture problems. A. Klečka mentioned the preparations which are being made for a permanent exhibit of forage crops in the Agricultural Museum. In a future control of forage crop production and consumption of fodder units will be carried out by several members of the Commission. (*Zemědělský pokrok.* 4. 246. 1937).

The third forage crop course was held in June, 1937, in the vicinity of Rožnov (*Zemědělský pokrok.* 4. 241-2. 1937). In addition to numerous Czechoslovakian farmers and specialists, visitors from Jugo-Slavia, Rumania and Poland took part in this course. E. Vencl, founder of the grass seed production industry near Rožnov, discussed the development of this industry, which is now of great value to the mountain farmer. Grass cultures were visited and explanations furnished by Brada, Demela, Šamšula, etc. On experimental plots on the summit of Radhošt visitors saw how *Nardus* swards may be improved by resowing and proper cultivation. Model pastures were demonstrated in several estates. In the Vitkovice iron-works the visitors saw the manufacture of nitrogenous and phosphoric fertilizers. A special publication will present all lectures, discussions and new experiences obtained during this course.

VIENNA, 1937.

The Association of Plant Breeders, Vienna, popularly known as "the Z", celebrated the twenty-fifth anniversary of its existence in June, 1937. Representatives of ten countries were present. An account is given by Baresch in *Z. Züchtg.* A. 22. 181-6. 1937, with brief summaries of the papers read, the titles of which are as follows : The sugar beet as particularly suitable material for genetic and botanical study (O. Munerati, Rovigo, Italy) ; The growth of leaves and the inheritance of leaf form (F. v. Frimmel, Brno, Czechoslovakia) ; The role of nucleus and protoplasm in inheritance (K. Hoefler, Vienna) ; Day length and plant growth in their mutual relations with breeding (L. Kopetz, Vienna).—G.M.R.

BERLIN, 1937.

The Eleventh World Dairy Congress was held in Berlin, August 22nd to 28th, 1937. The members of the Congress came from thirty-one different countries; twenty-six subjects were discussed from various points of view in 413 papers. The Scientific Reports of the Congress are published in three volumes* obtainable through booksellers. A fourth volume containing discussions and a report of the business transactions of the Congress is supplied only to Congress members.

The following papers may be of interest to grassland workers :

Section 1. Milk production : dairying in the tropics.

Question 2. The feeding of dairy cows on home-grown produce.

Axelsson, J. (Sweden.) [Transition in Sweden to the feeding of dairy cows on home-grown produce, and some consequences.] 1. 90-4. (German.)

Bitzan, R. (Austria.) [The effect of using home-grown fodder upon the profitability of milk production in hill country.] 1. 94-101. (German.)

Buenger. (Germany.) [Fodder value and effect of the marrow stem kale.] 1. 101-6. (German.)

Christensen, A. S. (Denmark.) [The feeding of dairy cows with home-grown produce]. 1. 109-12. (German.)

Kolbai, K. T. (Hungary.) [The establishment of new grassland in Hungary, its importance and the technique employed.] 1. 115-8. (German.)

Liebscher, K. (Austria.) [Ensilage on the dairy farms of the Austrian arid region.] 1. 126-30. (German.)

Loehr, L. (Austria.) [The use of home-grown fodder in relation to the profitability of milk production.] 1. 134-42. (German.)

Lavriano, E. M. di. (Italy.) [Variation in the quantity of acid requisite for ensilage by the A.I.V. method in relation to the stage of development of the plant.] 1. 142-3. (French.)

Mueller-Lenhartz. (Germany.) [Home production of protein fodder.] 1. 144-5. (German.)

Newlander, J. A., Ellenberger, H. B., and Jones, C. H. (U.S.A.) The digestibility and nutrient content of timothy and alfalfa when ensiled. 1. 145-7. (English).

Nicolaisen, W. (Germany.) [The value of marrow stem kale in the provision of home-grown fodder for the dairy cow.] 1. 148-52. (German.)

——————— [The reorganization of dairy farming on a home-grown fodder basis.] 1. 152-4. (German.)

Piraux, E. (Belgium.) [The ensilage of green fodder in Belgium.] 1. 154-7. (French.)

Piukovich, J. von. (Hungary.) [The fodder value of the pastures in the Great Hungarian Plain with special reference to the production of milk.] 1. 157-61. (German.)

Smeyers, F. (Belgium.) [The rational feeding of dairy cows by means of home-grown fodder.] 1. 164-8. (French.)

Vezzani, V. (Italy.) [The feeding of dairy cows with home-grown fodder.] 1. 174-80. (French.)

Virtanen, A. I. (Finland.) [Milk production on home-grown fodder.] 1. 180-7. (German.)

Watson, S. J. (England). The value of silage and artificially dried grass in the feeding of the dairy cow. 1. 191-6. (English.)

Eskedal, H. W. (Denmark). [Some Danish experiments in the use of hay and silage as fodder for dairy cows.] 1. 196-200. (German.)

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*Berlin, Reichsminister für Ernaehrung und Landwirtschaft. Wissenschaftliche Berichte des XI. milchwirtschaftlichen Weltkongresses. 22. bis 28. August 1937. Berlin. [Scientific reports of the Eleventh World Dairy Congress, Berlin, August 22nd to 28th, 1937]. 3 vols. 25 × 18, pp. 522. 581, 508. Hildesheim, Germany : Verlag Molkerei-Zeitung. 1937.

WITT, M. (Germany.) [On the question of the correct utilization of pasture herbage.] 1. 200-5. (German.)

BOTTINI, E. (Italy.) [On the biochemical processes which take place during mowing. A study of the question in lucerne and clover (*Trifolium pratense*).] 1. 375-6. (French.)

Section 2. Treatment of milk : improvement of quality.

Question 2b. The keeping properties of butter.

RICHTER, F. (Germany.) [The effect of feeding cows on vetch grain, disembittered and untreated respectively, upon the composition and quality of milk and butter.] 2. 145-9. (German.)

Question 3. The Pasteurization of milk with reference to the different kinds of cheese.

JÖRGENSEN, H. (Denmark.) [Feeding and the effect of the fodder upon the utility of milk for the making of cheese.] 2. 199-203. (German.)

CALCUTTA, 1938.

The silver jubilee meeting of the Indian Science Congress will be held in Calcutta from January 3 to 9, 1938. This meeting is of particular interest in that an English delegation of nearly 100 members of the British Association for the Advancement of Science will be present. The sections include agriculture, physics and mathematics, chemistry and applied botany, zoology and ethnography, botany, geology and medical research. The procedure of the British Association is followed ; when the sections meet separately, each section is presided over by its own president, elected annually. The presidents of the sectional meetings are all residents in India. The Congress will be opened by the Viceroy of India. (*Science.* 86. 462. 1937.)

OXFORD, 1938.

The Third Oxford Farming Conference is to be held in the Hall of the Taylor Institution, Oxford, on January 4 to 7, 1938, under the joint auspices of the School of Rural Economy, the Agricultural Economics Research Institute, and the Institute for Research in Agricultural Engineering of the University of Oxford.

The following are among the papers on the programme :

J. A. S. Watson : The maintenance of fertility and the Land Fertility Scheme.
J. A. Hanley : Our grassland.
D. G. Brown : How we work grassland in the North.
C. S. Orwin : Introduction to discussion on alternate husbandry.
W. S. Mansfield : The practice of alternate husbandry on heavy land.
R. W. Fisher Crouch : The practice of alternate husbandry on light land.
F. Rayns : Some views on arable manuring.
H. V. Garner and S. J. Wright : Manure distribution.
H. G. Sanders and F. H. Garner : Silage.
W. H. Cashmore : Production of high-quality hay.
S. J. Farrant : Hay and silage on the farm.
S. J. Watson : The conservation of fodder crops on the farm.
A. Bridges : Some economic aspects of grass conservation.
D. Skilbeck : Weed control in mechanized farming.

These papers will probably appear in a Report of the Conference to be published in *Farm and Machine*, Vol. 5. 1938.

EDINBURGH, 1939.

In accordance with a resolution of the International Committee and with the decision of the Organising Committee elected by the Genetical Society of Great Britain, the Seventh International Congress of Genetics will meet in Edinburgh in 1939, probably from August 23rd-30th inclusive. Professor F. A. E. Crew, Institute of Animal Genetics, University of Edinburgh, Edinburgh, 9, has been appointed General Secretary to the Congress and to him all correspondence concerning it should be addressed.

ANNOTATIONS

GREAT BRITAIN. (410)

The scope of the Aberystwyth and Cambridge Bureaux.

On the recommendation of the British Commonwealth Scientific Conference, 1936, the Imperial Bureaux of Plant Genetics for Herbage Crops, Aberystwyth, and for Crops other than Herbage, Cambridge, will from January 1, 1938, be known respectively as the Imperial Bureau of Pastures and Forage Crops, Aberystwyth, and the Imperial Bureau of Plant Breeding and Genetics, Cambridge.

From that date the literature on the genetics and cytology of herbage and forage plants will be dealt with by the Imperial Bureau of Plant Breeding and Genetics, Cambridge. All other aspects of these crops will, as hitherto, be covered by the Imperial Bureau of Pastures and Forage Crops, Aberystwyth.

Enquiries should in future be addressed to the appropriate Bureau.

Abstracts relating to the genetics and cytology of pasture and forage plants will cease to appear in *Herbage Abstracts* as from Vol. 8, No. 1, and will commence to appear in *Plant Breeding Abstracts* from Vol. 8, No. 3, onwards. The Aberystwyth Bureau will extend the scope of the Plant Biology section of *Herbage Abstracts* to cover a wider field in plant physiology and related subjects.

GERMANY. (43)

K. Schneider-Kleeberg.

It is with profound regret that the death of Herr Karl Schneider-Kleeberg on October 18th, 1937, in his 71st year, is reported. Herr Schneider-Kleeberg's pioneer work in the development of modern grassland technique in Germany and his untiring activity in the field of grassland research have won recognition beyond the confines of his own country, and it was a source of much gratification to many of his overseas colleagues that he was able to be present at the recent Fourth Grassland Congress.

SPAIN. (46)

Carlos Pau.

The sudden death of Carlos Pau, the Spanish botanist and editor of *Cavanillesia*, on the eve of his eightieth birthday, is announced in *Cavanillesia*, Vol. 8. No. 8. 1937. This number of the journal, which was to have appeared as a jubilee number in honour of Señor Pau, is now published in his memory.

A list of his publications from 1885 to 1937 (pp. 115-32) includes some articles on grasses and legumes.

ESTHONIA. (474.2)

Developments and achievements in crop research.

An account of the developments and achievements of research work in plant cultivation in Esthonia during the period of its autonomy is given by E. Terasmäe in *Suom. Maataloust. Seur. Julk.* No. 34. 101-20. 1937. Before the country became autonomous, research and experimentation in plant cultivation were almost negligible, and it was only after that date that investigational work was established in its present position.

An important centre is the Research Institute of Raadi, near Dorpat, where the professors of the University act as heads of the different departments. This Institute corresponds to the Agricultural Research Institute in Tikkurila, Finland. The head of the Department of Plant Biology is Professor N. Rootsi ; in this Department the many-sided experiments in plant cultivation are conducted. Variety trials are carried out with all the most important plant species. In addition the cultivation possibilities of *Medicago sativa*, white *Melilotus officinalis*, *Helianthus annuus*, *Zea Mays* and *Brassica oleracea* are being investigated. Comprehensive experiments have also been conducted on fallowing, seeds mixtures, methods of sowing and time of sowing.

The work accomplished at the Institute for Plant Breeding at Jögeva is of great importance for the development of crop cultivation in Esthonia. In the Cereal Department (Head : M. Pill), new, valuable varieties of oats and barley have been developed. In the Department for Meadow Plants (Head : M. Mets) new resistant and high yielding strains of many species of meadow plants have been bred.

Of great importance for the development of the extensive moorland areas of Esthonia is the Tooma Moorland Experiment Station (Director : L. Rinne) where research and experimental work were in progress before the country became autonomous.—R.P.J.

NETHERLANDS. (492)

Chronica Botanica.

As from February, 1938, *Chronica Botanica* will be issued every second month and no longer as a year book. The annual subscription will be reduced from 15 to 7 guilders. The new periodical will continue to give all the essential information contained in the old year book, and will include some important new sections as well. Like the year book the new *Chronica* will aim at promoting goodwill and international co-operation among plant scientists. Results of research will be published only in the first two sections. The world list of plant science institutes and societies will appear as a supplement. The contents of the reorganized *Chronica* will be as follows :

1. *Scientific Communications* : a medium for the quick publication of short preliminary notes on the results of recent research or announcing new discoveries.
2. *Forum Botanicorum* : Discussions, Announcements, Letters to the Editor.
3. *International Congresses* : Detailed programmes, short reports, decisions, resolutions, etc.

4. *Quotations* : from recent articles of general and timely interest.
5. *Miscellaneous news* : News notes of all kinds of plant science institutions, experiment stations, gardens, etc., including notes on new research projects.
6. *Herbarium and Museum news* : Expeditions, new collections, lists of new acquisitions, etc.
7. *Personalia* : Appointments, retirements, resignations, deaths (short obituaries), miscellaneous, new addresses.
8. *Queries* : Requests for co-operation and information, exchange offers.
9. *New Periodicals* : Short accounts of new plant science periodicals, changes in existing periodicals.
10. *New Books* : Short reviews of new plant science books.

JAPAN (52)

In Bulletins Nos. 1 and 2 (1935 and 1937) of the Kawase Grass Farming Research Institute, by T. I. Kawase, 39 Todacho, Nishinomiya, Japan, entitled respectively "The possibility of sheep farming in Japan," pp. 34, and "A consideration of grass farming in Japan," pp.44, the need for extending grassland cultivation is emphasized from the points of view of extension in the woollen industry and increased consumption of dairy produce in the country.

With regard to the production of wool, suitable conditions of climate, soil and topography are considered. Many areas in Japan are covered with kaya (*Miscanthus sinensis*) or bamboo grass, mostly unsuitable for sheep farming, and there is urgent need for cultivation of the better grasses. The advantages of keeping livestock under natural conditions (as opposed to the one farmer—one sheep system advocated by the Government) are stressed.

Study of possible areas for sheep farming in Japan has been made and the author concludes that it is impossible to raise merino on the mainland and, although Corriedale could be raised satisfactorily, the area is inadequate for the 3 or 4 million sheep necessary for Japan's domestic requirements.

To remedy distress in the farming community, parish commons could be utilized as grazing areas during the period of rice cultivation (April to October). After harvesting the rice crop the fields should be sown with Italian rye grass on which sheep could be fed from about the end of November to April. Of the areas Manchuria, Korea and North China, the first is not very promising for sheep rearing but, with a suitable selection of grasses, Korea and North China, particularly Shantung, are the only places from which good wool may be expected for Japan's growing woollen industry.

The causes of unsuccessful grass farming in Japan are lack of care in the selection of seed and deficiencies in management. Problems specific to Japan in connexion with grass farming and livestock rearing are discussed with special reference to economic aspects. Grasslands are chiefly used for hay under the present system, but if the one farmer—one animal practice is continued, grass should be the main food of the animals. Grass areas become more productive when used for feeding cattle. There are at present no data as to whether grass farming (as practised in Europe and America) or cultivation of the fields (as practised in Japan) is the more economic. It has been shown, however, that from the point of view of starch equivalents grasses are more profitable than cereals, but starch equivalents from the wild grasses of Japan are very low. Conversion of the highlands into productive areas is advocated. On the mainland of Japan there are practically no areas planted to grass and even in

Hokkaido only one-fifth of arable lands is under grass. Here the chief plants are *Phleum, Dactylis* and *Trifolium pratense,* although occasionally there is red top (*Agrostis* sp.) and *T. repens.* There are scarcely any perennial grasses. Study should be made of species suitable for the country.

From a consideration of the history of grass farming, mostly in Europe, and of a world survey of such farming the author concludes that agriculture should not be considered less important than other industries and that a study of grasses is of fundamental importance. With a reduction in the cost of land in Japan grass farming might be extended and upland areas made productive.—B.M.

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